Welfare, productivity and qualitative traits of egg in laying hens reared under different rearing systems

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The welfare, production performance and some qualitative characteristics of eggs obtained under three different rearing systems (conventional, organic and organic-plus) were compared. Three homogeneous groups, each of 120 White Leghorn hens, fed the same diets, were assigned to different rearing systems and data were recorded for 1 year. The welfare indicators were the following: first impact, behavioural patterns, tonic immobility and plumage status. Productive performance was recorded (% deposition; egg weight) and some qualitative traits (Haugh index, yolk colour, yolk, albumen and egg shell weight) were evaluated. Well-being was greatly affected by rearing system. The best welfare status was observed in hens of the organic-plus group, whereas the worst was in the conventional group (caged hens). Caged hens showed little interest or fear of observers, at times they had high tonic immobility and some aggressive pecking; the status of their plumage was very poor. On the contrary, caged hens produced more eggs, even if their qualitative traits (Haugh index and yolk colour) were worse than the organic-plus eggs. The intense motor activity of organic hens and the concurrent intake of grass reduced their productive level; further egg deposition seemed more affected by seasonal variation.

Keywords: hens; welfare; egg characteristics; behaviour; organic production

INTRODUCTION

The intensive farming systems have considerably modified the welfare status of animals, constraining them to perform under conditions very different from the natural ones. In recent years the growing interest for the environmental sustainability, animal welfare, and "ethical quality" of the animal products has favoured studies directed to identify less intensive and more animal-friendly production systems.

Being that the rearing system of laying hens is one of the most intensive housing systems, the EU Directive 1999/74 gave minimum standards to improve such uncomfortable conditions. The standards should be maintained until the year 2012 when all un-enriched cages will be banned. Foreseeing this event, more extensive rearing systems and thus more concern for animal welfare have been proposed. In the light of this, the organic production system theoretically has a good chance of success, due to more extensive conditions it provides for the animals. The egg characteristics should also be of concern due to the strict controls in each stage of the productive phase, the ban of pharmacological treatments, the higher space allowance and the presence of grass (EC Council Regulation No 1804/99). Original works (Hughes *et al.*, 1985; Casagrande *et al.*, 2001) and review (Kouba, 2002), have analysed the effect of conventional and free-range housing systems on the welfare and productivity of laying hens. It was found that extensive rearing conditions allow a broad range of behaviour patterns and cope better the natural spatial and social needs (Martrenchar *et al.*, 1997). Regarding the genotype to be used in order to assure a good welfare status, the recommendation of the Network for Animal Health and Welfare in Organic Agriculture (2002)

advises against using commercial breeds due to the strong selective work carried out that has suppressed some behaviour patterns. Furthermore these strains, selected to produce under highly controlled conditions, seem to be quite unsuitable for more extensive systems, that provide more natural but poorer living conditions (less controlled environment and less equilibrated rations). Therefore, the use of less selected strains, that have drastically declined in number (Carolyn and Sponenberg, 2000), could be a valuable alternative.

The aim of the present work was to analyse the welfare conditions and productive performance of White Leghorn hens reared under the standard housing system or two organic production methods with different pasture availability.

MATERIAL AND METHODS

Four-hundred 1-day-old female chicks of the White Leghorn breed were reared during the first 5 weeks at the experimental Farm of the University of Perugia. At 5-weeks-of-age three groups, each of 120 birds, were randomly constituted. The first group was kept at the experimental farm, while the other two were transferred to a different location, labelled for organic production. The data were recorded started from 20-wks-of-age. All animals were vaccinated against Marek and Newcastle disease; no other pharmacological treatments were given. None of the animals had their beaks trimmed.

The rearing systems of the birds were the following:

- CONTROL: At 18-weeks-of-age the hens were put in cages (4 hens/ cage with space availability of 0.75 m^2) of three-tier batteries that were provided with linear automatic feeders and waterers. The building had a conditioned regime. The feed was given *ad libitum* and had the same standard compositional and chemical characteristics as the organic groups.
- The ORGANIC group differed from the ORGANIC-PLUS group with respect to different out-door area availability (4 *vs* 10 m^2/bird). Both organic groups were reared in a covered, straw-bedded house (0.10 m^2/bird) and the birds had access to a paddock provided with mature trees, bushes and hedges. Inside the house there was a small hut with nests (1 per 5 hens) and perches. Along the front of the nests there was, a conveyor belt that collected the eggs twice a day.

More than 80% of the feed ingredients (maize, wheat and whole soybean) were organically grown, as established by Regulation 1804/99.

Data concerning percentage of deposition were recorded weekly during the entire productive cycle. Egg traits were collected (n=40 per group) twice a week during three consecutive weeks in winter (1), spring (2), summer (3) and autumn (4). All eggs (960 for each rearing system) were stored at 5 °C until analysed. The physical analyses of eggs included: whole egg weight, weight of shell, thickness of shell according to Mueller and Scott (1940), weight and colour of yolk (Roche scale), weight of albumen and height of albumen (Haugh unit) using an electronic gauge (Bukley *et al*., 1981).

During the same periods in which the eggs were collected, samples of grass were cut from random locations in the areas where the hens pastured and analysed.

The chemical composition of the feed and grass was determined according to AOAC (1995).

The stress status of animals was monitored by evaluating *the initial interest*, that was expressed as percent of hens that showed attention to the observer (Lewis *et al*., 1997). Behaviour observations were recorded with *focal animal sampling* (Martin and Bateson, 1986), twice a week in the morning (9:00-12:00), for three consecutive weeks and during four periods: 26-27-28 wks of age, 34-35-36 wks, 42-43-44 wks and 50-51-52 wks. Thirty hens were randomly chosen for each housing condition: 2 operators, after waiting 5 min to allow the birds to adapt to human presence, directly observed the following activities: feeding, locomotion (running, walking and flying), resting (crouching with open or closed eyes and standing with closed eyes), standing (with open eyes), scratching, comfort, dust bathing and social interactions. Within the social interaction, gentle and aggressive pecking were recorded; to establish if a peck was gentle or aggressive, the reaction of the receiving bird was observed, if the bird ran away or reacted with a peck to the head, the peck was evaluated as aggressive. For the control group, the peck was considered aggressive if directed to the head.

The various activities were recorded on a purpose-designed table and their respective frequencies were calculated as the percent of total observed behaviours. The *tonic immobility* was also evaluated. For this test, which expresses the stress response (Scott and Moran, 1993) each hen was manually inverted and restrained in a cradle for 10 sec and then released. The time needed for the bird to right itself was recorded up to a maximum of 3 min. Another observation to establish the welfare status concerned the plumage conditions, examined in five regions of the body: neck, breast, wing, back and tail. The scale used (Tauson, 1984) ranged from 0 (denuded) to 4 (excellent condition).

Data were analysed by linear models (STATA, 2005) and the significance of the differences was assessed by the t-test; the interactions (season*system) were always significant.

Since no differences on the welfare status between observation times and seasons were found all data were pooled to obtain a mean value.

RESULTS AND DISCUSSION

A comparison between the characteristics of feed and grass (Table 1) showed, as expected, that grass had less dry matter (DM), crude protein (CP), ether extract, hemicellulose and metabolizable energy (MJ kg^{-1} d.m.); while grass had greater amounts (on DM basis) of crude fibre, NDF (Neutral Detergent Fibre), ADF (Acid Detergent Fibre), ADL (Acid Detergent Lignin), and cellulose.

It should be noted that the paddock of the organic group was almost devoid of grass, showing that 4 m^2/hen is not sufficient –at least in a Mediterranean environment- for maintaining grass in the paddocks. On the contrary, that of the organic-plus group always had some grass available.

Table 1. Chemical characteristics of feed and grass (seasonal mean).

Chemical composition		Feed	Grass
Dry matter	%	89.95	27.81
Crude protein	% d.m.	17.56	15.45
Ether extract	"	4.40	2.48
Crude fibre	"	3.26	19.61
Ash	"	9.82	10.19
NDF – Neutral Detergent Fibre	"	18.46	38.85
ADF – Acid Detergent Fibre	"	6.09	25.48
Cellulose	"	4.61	21.12
ADL – Acid Detergent Lignin	"	1.48	3.86
Hemicellulose	"	12.37	13.43

The effect of rearing system on the well-being status was relevant (Table 2). Under organic conditions most of the hens, 73.7% in the organic-plus group and 63.5% in the organic group, showed attention towards the observers; on the contrary, this "*initials interest*" was manifested in only 13.1% of the caged group, while the remaining birds showed fear. Most of the organic birds used the external area (68.6% organic, 75.2 % organic-plus). The activity patterns of the three groups were very different due to the fact that only organic hens expressed many aspects of their repertoire (walking, running, wing-flapping, scratching, dust bathing). The caged hens spent most of their time on feeding, standing, sleeping and in comfort behaviours. The moving activity was less in comparison to the other two groups (25.6% *vs* 29.9 and 30.9%) and consisted in walking in one's place. The organic-plus hens differed from the organic ones in that they carried out scratching activity more frequently and spent less time in other behaviours (standing, laying, sleeping, comfort, and social). The highest incidence of aggressive pecks occurred in the organic group presumably due to the competition for the scarce grass in the paddock. In turn, the higher incidence of pecking in caged hens with respect to the organic ones could be due to the restricted available that frustrated the animals and inhibited the expression of a number of natural behaviours. According to Keeling (1984), the greatest restriction for animals living in intensive housing system is the lack of space. Al-Rawi and Craig (1975), observed that the rate of social interaction increased as space decreased. Mench and Keeling (2003) recorded the most fighting at the feeder caused by competition for feed.

Table 2. Effect of housing system on behaviour.

Housing system		Control	Organic	Organic-plus	SEM
First impact	%	13.1[a]	63.5[b]	73.7[b]	4.7
Animal outside	"	-	68.6[a]	75.2[a]	6.0
Feeding	% all activities	19.8[b]	8.4[a]	7.1[a]	1.0
Move	"	25.6[a]	29.9[b]	30.9[b]	0.57
Scratching	"	-	21.9[a]	37.6[b]	2.7
Standing	"	26.9[c]	17.3[b]	14.0[a]	1.0
Laying	"	5.5[b]	4.4[b]	1.4[a]	0.3
Sleeping	"	5.6[c]	3.4[b]	1.4[a]	0.3
Comfort	"	9.2[c]	8.3[b]	5.0[a]	0.3
Dust bathing	"	-	3.7	3.5	0.3
Aggressive pecking	"	1.8[b]	3.2[c]	0.8[a]	0.2
Gentle pecking	"	3.0[c]	1.0[b]	0.3[a]	0.2
Tonic immobility *	sec.	182.2[c]	55.2[b]	18.2[a]	12.6

n=30 per group, a..c: P<0.05

The different conditions of well-being due to the housing system were confirmed by the tonic immobility test: the organic hens reacted much more rapidly than the caged ones (55.2 *vs* 182.2 sec.), the best response was observed in the organic-plus hens that reacted in only 18.2 seconds. In preference studies, Dawkins (1980), found that hens prefer an outside run to a cage, and also if preference in itself is not indication of suffering, this is in accord with our finding that birds with an access to the outside area showed a greater well-being status. The plumage conditions (Table 3) were very poor in hens kept in cages. Their necks were almost denuded and showed damage due to abrasions. On the contrary, the plumage status was very good in both the organic groups.

Table 3. Plumage status as affected by rearing system.

	Control	organic	organic-plus	SEM
Neck	1.1[a]	3.3[b]	3.9[b]	0.2
Breast	1.9[a]	3.7[b]	4.0[b]	0.1
Wings	1.7[a]	3.7[b]	4.0[b]	0.2
Back	1.7[a]	3.7[b]	3.9[b]	0.2
Tail	1.8[a]	3.1[ab]	3.9[b]	0.1
total	8.2[a]	17.5[ab]	19.7[b]	0.3

n=30 per group , a..b: P<0.05

Animals that spent a lot of time foraging (organic-plus) showed a very low incidence of feather pecking, in agreement with Huber and Sebo (2001). Feather pecking and cannibalism can represent a big problem, even in free range housing systems, these behaviours were not observed in our trial. This was probably due to the genetic strain used, and the fact that they were kept in small groups. With reference to egg deposition, the results showed that the deposition was affected by season and by housing system (*Table 4*). Organic birds showed a lower deposition level than the control (organic 64.1% *vs.* 61.0% *vs.* control 73.9%) probably due to the more intense motor activity and to the concomitant lower energy and protein ingestion which was diluted by grass intake –mainly in the organic-plus group. Furthermore, compared to the control, the production intensity of the organic birds was more affected by seasonal conditions (temperature and photoperiod). During the favourable season in the middle of the deposition period (8-25 wks), the data were the same for all the groups; the control animals, however, started to produce faster and showed higher production persistence. The OP trend was particularly negative, suggesting that the control of light length could be beneficial for deposition. The total egg weight and egg components were negatively correlated with deposition intensity (- 0.27 P< 0.01 data not shown). The more productive birds, independent of group and season, produced lighter eggs. Thus, the organic-plus group generally showed heavier eggs mainly due to lower production intensity (Hughes *et al*., 1985).

Table 4. Effect of housing system and season on main characteristics traits of eggs.

Housing system		Control				Organic				Organic-plus				Root
Season		1	2	3	4	1	2	3	4	1	2	3	4	MSE
Deposition	%	84.6	81.9	65.3	64.7	71.9	79.6	54.2	47.8	72.0	80.0	51.2	42.5	7.5
Egg weight	g	55.4	57.7	55.6	55.8	55.1	57.3	56.3	58.3	56.8	57.9	57.8	60.6	1.10
Yolk weight	"	17.3	17.4	17.3	17.2	17.5	17.7	17.8	17.7	17.3	17.6	18.2	18.5	0.39
Albumen weight	„	31.1	33.2	31.2	31.6	30.4	32.3	31.3	33.1	33.3	31.8	30.7	33.8	1.13
Shell thickness	mm	0.36	0.39	0.38	0.40	0.38	0.40	0.39	0.40	0.40	0.39	0.40	0.40	0.01
Haugh unit		87.5	88.1	86.6	86.9	87.5	89.0	88.8	88.6	87.3	88.4	89.0	91.1	0.36
Yolk colour	Roche s.	9.7	9.8	9.7	9.1	9.8	9.9	8.2	9.4	10.5	10.7	8.8	12.0	0.43

n=120 per group/season.

As expected, the shell thickness reached the lowest value in summer independent of farming system. The highest mean values of this trait were found in eggs from organic and control hens (0.40 mm *vs* 0.38 mm). The greater thickness could be due to the ingestion of little stones from the ground and to the higher synthesis of vitamin D_3 (Bar *et al*., 1999) as a consequence of greater exposure to sunlight. It is well known that vitamin D is synthesized through a photochemical reaction requiring ultraviolet B photons (Wang *et al*., 2001). According to Penz and Jensen (1991), albumen deposition is greatly affected by the level of dietary protein and the organic-plus hens diluted dietary protein by ingesting a large amounts of grass. Egg quality, expressed as Haugh unit, was always high in the OP eggs, and was superior to the other two group during the final productive phase; this was probably due to less stress in the oviduct tract of the OP hens.Yolk colour was also positively affected by grass consumption; Roche scale highest value was found in eggs from organic-plus hens (mean value: 10.6).

The seasonal variations in yolk colour recorded in both organic groups reflected differences in grass ingestion which also reflects variations in the intake level of grass carotenoids that were observed in another work (data not shown). The yolk colour reduction in summer were also caused by the high temperatures that reduced the feed ingestion in free-range birds, while in the controlled housing system (caged hens) the reduction was not significant. Based on the results presented, it can be concluded that both organic-rearing systems gave a satisfactory welfare status to hens that spent most of their time outside and they could express their natural repertoire. The living conditions were better for the organic-plus birds due to the possibility of a more intense foraging activity, and a satisfactory space requirement (Appleby *et al.*, 1992). The benefit to egg quality was observed mainly with respect to albumen quality and yolk colour. The values were equal to the maximum obtainable with natural xanthophylls (ASPA, 1996). While raising hens according to the organic production system greatly enhanced the welfare conditions of the animals, the productive performance were markedly lower. Further research on the effect of pasture composition, season and diets on egg quality (tocopherol, lutein etc.) should be further investigated to give to the consumer other reasons of choice.

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